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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants:	H. SHIMOKAWA, et al.
Application No.:	09/972,178
Filed:	October 9, 2001
For:	PB-FREE SOLDER-CONNECTED STRUCTURE AND ELECTRONIC DEVICE
Art Unit:	1775
Examiner:	J. J. Zimmerman

FURTHER DECLARATION UNDER 37 CFR § 1.132

I, Masahide OKAMOTO, a citizen of Japan, residing at 29-3-410, Yayoidai, Izumi-ku, Yokohama 245-0008, Japan, DECLARE THAT:

1. I incorporate herein by reference, in their entirety, Items 1-23 on pages 1-7, and Figure 1, of my DECLARATION UNDER 37 CFR § 1.132 signed June 9, 2003, in connection with Application No. 09/972,178, filed October 9, 2001 (hereinafter "the above-identified application").

2. I have reviewed the Office Action mailed July 21, 2003, in connection with the above-identified application.

3. In order to determine differences between a specimen (1) formed by plating only a single layer of Sn-2Bi (having a thickness of 10 μm) on a copper lead of a semiconductor device, prior to reflow soldering, the single layer of Sn-2Bi being directly in contact with the lead; and a specimen (2) as in Example 44 in Table 3 of U.S. Patent No. 6,110,608 to Tanimoto, et al., formed by plating two layers, an inner Sn-2Bi layer (having a thickness of 8 μm) and an outer Sn-10Bi layer (having a thickness of 2 μm), on a layer of Ni (having a thickness of 0.5 μm) directly in contact

with a copper lead of a semiconductor device, prior to reflow-soldering, experimentation discussed in the following was carried out.

4. The determination was conducted using the specimen (2) formed by plating the two layers on a layer of nickel, so as to correspond to Example 44 in Table 3 of U.S. Patent No. 6,110,608 to Tanimoto, et al., indicating the presence of a Ni base plated layer. See column 10, lines 4-8, of U.S. Patent No. 6,110,608.

5. Specifically, the following specimens were prepared:

(a) Invention specimens: Specimen (1) was prepared by plating the single plated layer of Sn-2Bi directly in contact with the copper lead, to form the single layer described in connection with specimen (1) in Item 3 herein.

(b) Comparative specimens (corresponding to Example 44 in Table 3 of U.S. Patent No. 6,110,608 to Tanimoto, et al.): Specimen (2) was prepared by plating the copper lead with Ni to form the base plated layer; and, thereafter, the first plated layer of Sn-2Bi and the second plated layer of Sn-10Bi were sequentially plated on the Ni of the base plated layer, to form the Ni layer, and the two layers, described in connection with specimen (2) in Item 3 herein.

6. Solderability (wettability) tests of Invention specimens and Comparative specimens were conducted according to the solderability test set forth in U.S. Patent No. 6,110,608 to Tanimoto, et al. (see column 7, lines 52-57 and column 10, lines 11-16), and as set forth in the following:

(a) Each specimen was held in an air bath for 48 hours at 170 °C.

(b) Reflow processing was then conducted at a maximum temperature of 220 °C.

(c) After completion of the reflow processing, the specimens were subjected to rapid water-cooling (re-solidification of molten plated layers).

(d) The specimens were then dipped into a molten Sn-Pb eutectic solder at 230 °C for two seconds, and thereafter the specimens were pulled up from the molten solder.

(e) A solder wetted area of each specimen was measured and compared with the specimen dipped area, and the measured solder wetted area with respect to the specimen dipped area was expressed as a percentage (the specimen dipped area was 3 mm x 5 mm times 2 (front and back side surfaces). A greater percentage means greater solderability (wettability).

7. The results of the solderability (wettability) tests are shown in the following Tables 1 and 2, Table 1 showing solderability of specimens, according to the present invention, as in Item 3 and Item 5(a); and Table 2 showing solderability of Comparative specimens as in Item 3 and Item 5(b).

Table 1

Specimen No.	Front Side (mm^2)	Back Side (mm^2)
1	12.5	12.9
2	14.1	13.5
3	13.5	13.9
4	12.5	13
5	13	12.2
6	11.3	12.2
7	12.2	13.8
8	14.6	13.3
9	14.8	14.7
10	12.7	12.2
Average Rate of wetted area	13.145 mm^2 87.6%	

Table 2

Specimen No.	Front Side (mm^2)	Back Side (mm^2)
1	11	10.1
2	12.4	11.8
3	12	10.7
4	11.3	10.3
5	11.4	10.6
6	10	9.8
7	12.2	10.6
8	10.2	9.7
9	11.3	12.1
10	9.7	10.2
Average Rate of wetted area	10.87 mm^2 72.5%	

8. Bond strength tests of Invention specimens and Comparative specimens were conducted according to the following procedure:

(a) Leads of the Invention and Comparative specimens were bonded to Cu pads on glass-epoxy substrates by reflow soldering, with use of Sn-2.8Ag-15Bi-0.5Cu solder foils. The reflow soldering was performed at a maximum temperature of 220 °C, with the reflow processing being performed by conventional processing. Flux JS-64 was used when soldering.

(b) Flux was removed from the specimen by washing, after the reflow soldering.

(c) Tensile strength was measured by pulling perpendicularly bent portions of the leads (the bent portions were formed by bending lead portions upwardly) to the remaining portions of the leads, respectively, at a pulling rate of 5 mm/minute.

(d) The tensile strength was a maximum at the fillet portion and became constant at the flat portion.

9. The results of the bond strength tests are shown in the following Tables 3 and 4, with Table 3 showing bond strength using specimens according to the present invention as in Item 3 and Item 5(a); and with Table 4 showing bond strength using Comparative specimens as in Item 3 and Item 5(b).

Table 3

Specimen No.	Fillet Portion (kgf)	Flat Portion (kgf)
1	20.91	1.94
2	8.18	0.67
3	8.54	0.56
4	14.63	0.59
5	12.31	0.56
6	17.75	0.62
7	19.04	2.3
8	13.6	0.61
9	8.45	0.63
10	10.57	0.6
Average	13.4 kgf	0.91 kgf

Table 4

Specimen No.	Front Side (kgf)	Back Side (kgf)
1	8.57	0.45
2	12.74	0.41
3	13.06	0.42
4	7.33	0.35
5	10.5	0.4
6	8.84	0.39
7	11.46	0.42
8	7.66	0.5
9	9.1	0.43
10	12.23	0.43
Average	10.15 kgf	0.42 kgf

10. From Items 7 and 9 herein, it can clearly be seen that specimens according to the present invention have increased solderability and increased bond

strength as compared with specimens of Example 44 in Table 3 of U.S. Patent No. 6,110,608 to Tanimoto, et al., and thus specimens according to the present invention are superior to specimens of Example 44 in Table 3 of U.S. Patent No. 6,110,608 in solderability and bond strength.

11. In general, reflow soldering of leads of semiconductor devices is conducted at a temperature of 200°C to 240°C. If the devices were subjected to reflow soldering at 750°C (which is a welding temperature), the semiconductor chip or substrate for mounting would be damaged. Reflow soldering for semiconductor devices would not conducted at 750°C; thus, it make no sense to compare solder joints obtained under solder reflow conditions (220°C to 230°C) with those obtained under other conditions (at 750°C).

The undersigned Declarant declares further that all statements made herein of his own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signed this 9th day of December, 2003

Masahide Okamoto

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